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Environmental Health Center
Cincinnati, Ohio

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UNDATED

As some of you may know, the Environmental Health Center of the Public Health Service at Cincinnati, is conducting a rather broad program of studies on household sewage disposal systems as a cooperative project under the programs of the Office of the Administrator, Housing and Home Finance Agency and the Public Health Service. So far as possible, the individual undertakings are geared to immediate needs in the field as various problems come to the attention of the two agencies. In that funds are not unlimited the simultaneous study of the many problems in this field is not possible. However, we have attempted to get in some preliminary work on a number of items pending the opportunity for more detailed study.

Thus far our major efforts have been devoted to experimental investigation of factors of broad basic significance, such as the comparison of tank shapes, compartmentation and internal detail, the normal build-up of sludge and scum accumulations under household conditions, the spade work on soil clogging, percolation tests and the absorption field. Along with these have been undertaken, as opportunities present, investigations of other factors which have been the subjects of inquiry in this field for some time, such as tank seeding, the freezing aspects of shallow systems, the effect of chlorides on tank operation and the more recent topics of ground garbage and the effects of active chemical agents, such as found in the proprietary tank cleaning compounds.

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The work undertaken on the ground garbage topic thus far may be classed as preliminary to detailed study, particularly study of systems in the field which have operated for some time on sewage and ground garbage loadings.

There is considerable information assembled in the literature on ground garbage, the quantity produced, its character and its effects on various sewage treatment processes and we expect to rely largely on this for background information.

As for the quantity of garbage produced, it appears that there is considerable variation in the production per person in different areas and over the various months of the year in the same area. Over large geographical areas of the country the per-capita-per-day production ranged from 0.66 pounds to 1.05 pounds according to a 1941 survey by the U. S. Department of Agriculture (1). These figures appear larger on the average than figures from other sources. Production in the ten largest American cities for a one year period, from the same survey, ranged from 0.54 to 0.90 pounds per capita per day. Other sources, as Hering and Greeley (2), indicate a median production of 0.45 pounds per capita per day for 33 selected American cities; American Civil Engineers Handbook (3) 0.52 pounds per capita per day for 20 American cities; the American Public Works Association (4), for 48 cities, a median of 0.64 pounds per capita per day with a range of 0.19 to 1.51 pounds per capita per day. Many writers assume the daily per capita garbage production at 0.5 pounds although it appears from the sources of information above mentioned that a figure of 0.65 pounds might more nearly represent average production. The maximum rates appear to be in the late summer months when fresh vegetable consumption is at a peak. According to the American Public Works Association (4) data for eight cities, the peak month is August with a monthly rate of about 151 per cent of the average and the low month, February, with a production of about 70 per cent

of the average. Figures of Hering and Creely (2) indicate the peak as September with about 133 per cent of the average and the low as February with production at about 76 per cent of the average.

The composition of garbage, so far as it concerns sewage treatment, may be most easily understood by comparing it with sewage solids, in connection with which Rudolfs (5) has indicated the moisture content of garbage to be about 70 to 90 per cent and the comparison with domestic sewage solids to be as follows:

Table 1 - Comparison of Garbage and Sewage Solids

	Garbage Per Cent	Sewage Solids Per Cent
Volatile Matter	80-90	70-80
Ash	10-20	20-30
Grease	13-33	15-35
Nitrogen	0.4-1.5	4-6

It is seen from Table 1 that the garbage is higher in volatile matter than the sewage solids and that the nitrogen content of the garbage is considerably lower than that of sewage solids. The latter is of interest in connection with digestion and was thought to account for a tendency to slower digestion rates for garbage solids alone as compared with sewage solids or mixtures of the two. However, so far as it concerns the problem at hand, experiments by others have indicated successful digestion of mixtures of garbage and sewage solids. According to Rudolfs (5) the continuous addition of garbage is not detrimental but required digestion capacity (of sludge digesters) increases in direct proportion to the volatile matter added and the garbage volatile solids would require the same digestion time as sewage volatile solids, pound for pound.

As a start on study of the behavior of home septic tanks receiving ground garbage in addition to sewage solids we installed a duplicate of one of the 500 gallon single compartment tanks at the laboratory and, in addition to its regular sewage feed, added the daily garbage collected from a family of three and a family of two, totalling the garbage from five persons, which was subsequently ground in a household garbage grinder purchased for the purpose. The garbage-sewage tank was operated for about ten months in parallel with the duplicate tank which received sewage only. Both tanks received sewage loadings applied eight times a day on a schedule roughly approximating a household pattern. Samples were collected from effluent receivers for each tank after each feed and were composited for analysis in proportion to the volume of flow. Routine determinations on raw sewage and effluents included total and suspended solids together with the ash fractions, temperature and pH. Other determinations as B.O.D., chlorides and sulfides were made for all tanks on occasion.

The comparison of the effluent solids from the two tanks is of interest both from the standpoint of sedimentation efficiency and digestion. Due to difficulty in running a suspended solids determination on the raw garbage, a comparison on the basis of percentage removal of suspended solids, such as was made for all tanks receiving sewage only, was not possible. However, the suspended solids content of the effluents for the garbage-sewage tank, as well as all others, was obtained and the results for the two duplicate tanks are compared in Table 2.

Table 2 - Comparison of Effluent Suspended Solids - ppm.

Series	Dates	Tank No. 9 (Received Garbage + Sewage)	Tank No. 7 (Received Sewage Only)
II	Aug 20 - Sept 23, 1947	103	109
III	Oct 3 - Nov 8, 1947	123	123
IV	Nov 24 - Feb 15, 1948	118	128
V	Feb 23 - Mar 28, 1948	126	173
VI	Mar 30 - June 28, 1948	245	160

It will be seen from Table 2 that during the seven month period, August 20, 1947 to March 28, 1948, the garbage-sewage tank effluent contained less suspended solids than that of the tank receiving sewage only. Considering that both received the same amount of sewage solids, the tank receiving the garbage, in addition, must have performed at a higher suspended solids removal efficiency than the duplicate tank receiving sewage only. During the last three months of the series of operating periods, however, you will note that the performance of the garbage-sewage tank fell off considerably. This was a rather disturbing development, particularly as the project was forced to shut down for six months at that point because of lack of funds and the continuity was lost. The explanation of the drop in efficiency of both the tank receiving sewage only, and that receiving garbage and sewage, is that, due to accelerated sludge additions, both tanks were well loaded with sludge coming into the higher temperature summer months and the agitation due to increased rate of digestion was accompanied by a drop in suspended solids removal. The greater loss in suspended solids from the tank receiving garbage and sewage may have been due to the increased digestion activity resulting from the additional quantity of garbage solids in the tank.

In connection with the progress of digestion in the tank receiving garbage and sewage it is of interest to note that in this particular case the effluent pH's were about 7.3 to 7.5 for the five runs, and were essentially the same as for tanks receiving sewage only. It should be pointed out, however, that this tank was well seeded with sewage solids due to the accelerated additions of septic tank sludge applied to simulate operation under various circumstances of sludge accumulation in the short period of operation. In practice it is expected that the ratio of sewage solids to garbage solids will be much less than that of the experiment. Consequently, the value of adequate initial seeding should be stressed.

The comparison of effluents of the two tanks above mentioned on the basis of the volatile solids content is useful as an indication of whether or not digestion progressed as completely in the garbage-sewage fed tank as in the sewage fed tank. The comparisons are shown in Tables 3 and 4.

Table 3 - Comparison Volatile Solids Ratios - Total Solids

(1)	Total			Total Volatile					
	(2)	(3)	(4)	(5)		(6)		(7)	
	Raw Sew.	Effluent Tank No.9	Effluent Tank No.7	Raw Sew.		Effl.Tank No.9		Effl.Tank No.7	
Series	ppm.	ppm.	ppm.	ppm.	% of (2)	ppm.	% of (3)	ppm.	% of (4)
II	821	716	642	359	44	292	41	218	34
III	1034	721	716	492	48	217	30	231	32
IV	1300	819	772	606	47	217	26	199	26
V	1128	767	826	527	47	234	31	250	30
VI	1013	853	749	465	46	301	35	236	32

Table 4 - Comparison Volatile Solids Ratios - Suspended Solids

(1)	Total Suspended			Volatile Suspended					
	(2)	(3)	(4)	(5)		(6)		(7)	
	Raw Sew.	Effluent Tank No.9	Effluent Tank No.7	Raw Sew.		Effl. Tank No.9		Effl. Tank No.7	
Series	ppm.	ppm.	ppm.	ppm.	% of (2)	ppm.	% of (3)	ppm.	% of (4)
II	312	103	109	241	77	84	82	80	73
III	361	123	123	267	74	79	64	75	61
IV	550	118	128	427	78	92	78	93	73
V	476	126	173	353	74	86	68	99	57
VI	440	245	160	336	76	151	62	92	58

It may be noted from Table 3 that the ratio of volatile total solids to total solids, expressed as a percentage, is about the same for both tanks. The comparison in Table 4 on a suspended solids basis shows that the ratios of volatile suspended solids to suspended solids for the garbage-sewage fed tank tend to be higher than those of the sewage fed tank. It would appear from these developments that digestion, as represented by total volatile solids ratio comparisons appears to progress to an equal, or even greater extent, considering the higher volatile content of raw garbage solids, in the garbage-sewage fed tank. The higher ratios for the suspended volatile solids in the effluent of the garbage-sewage fed tank may indicate a comparatively greater proportion of raw or partly digested suspended matter in its effluent, as compared with the effluent of the sewage fed tank. If so, this may explain in part at least the soil clogging behavior of garbage-sewage tank effluent as compared to sewage fed tank effluent which I will discuss farther on.

The above is essentially the extent of our preliminary work on the application of garbage plus sewage to the tank. In order to provide a source of effluent from a tank receiving both sewage and garbage, for the subsequent

soil clogging studies, the contents of the tank above mentioned were transferred to another tank which has been kept in operation since the project was resumed after the shutdown. As for tank capacity requirements where the waste includes ground garbage the basis for conclusions must include field investigations to establish rates of sludge and scum accumulations and comparison of tank sizes against such accumulations. Although we have made tentative arrangements to examine such installations the funds to place a man in the field are not yet available. An attempt to make such examinations previously when we had the field personnel failed due to breakdown of local cooperation. For the time being I feel that the 50 per cent increase in liquid capacity recommended by the Joint Committee, F.H.A., and others is well taken. It is obvious that the solids load is increased considerably and that the periods between cleanings will be short unless more capacity is provided. Frequent cleanings are, as you know, financially uneconomical but there is another point to consider and that is that each operating run is accompanied by breaking in and tapering off periods during which tank performance is not at its best. The effect of short periods of operation between cleanings tends therefore to give lower performance in the long run and will shorten the life of the tile field. In my estimation adequate capacity is money in the bank, whether the tank receives garbage or not, and further, when the risk involves expensive and sometimes prohibitive relocations of clogged tile lines on small properties the provision of ample capacity is insurance at low cost. Do not skimp on tank capacity.

Concerning clogging of the soil by septic tank effluents the study is aimed first at learning the significance of the physical, biological and chemical factors after which an informed approach can be made on absorption system design. Possibly, out of this will come additional yardsticks of septic tank performance.

The physical factor, involving the possible stopping up of pore space available for passage of water, is obvious. The biological factor has been shown in agricultural studies to be important in continuously submerged soils, wherein in one study of soil cores treated with tap water the reduced permeability appeared entirely due to microbial sealing. Deterioration of soil structure due to chemical changes in the soil is also a factor of importance in agricultural circles, arising in the western States, particularly, where waters high in sodium added to soil were found to cause a deterioration in structure with consequent lowered permeability. The quality of irrigation waters must be carefully controlled.

We have been fortunate in obtaining the services of a soil scientist, Mr. T. W. Bendixen, with a background in agricultural drainage and irrigation research, for the soils work. In investigating the effects of the factors above mentioned as applied to septic tank effluents the experimental approach has been to set up various series of manually packed soil cores in 4 inch steel cylinders with a 1 inch layer of pea gravel above and below the 4 inch deep soil core. All cores were dosed with water until saturated and an initial percolation rate was established. The effluent was then applied at a rate sufficient to maintain a free head of liquid on the cores at all times. The volume of effluent applied and the percolate were measured daily. Percolation rates and amount of solids added to the cores were calculated daily as the basis for comparison of effects. Both natural and disinfected effluents were applied to natural and disinfected soils in order to observe the influence of the biological and physical factors. Various chemical treatments applied in water or septic tank effluents were tried.

The first studies will appear in the Part II report, "Studies on Household Sewage Disposal Systems, 1950," which is about to go to press. The

first studies include the dosing of soil cores with effluent from the tank receiving ground garbage and sewage, as mentioned previously, and I will briefly discuss this part of the work.

It should be borne in mind in considering these first studies that there has been opportunity to try out only one or two soils thus far, and the findings should not therefore be considered as generalizations.

It was found that soil clogging by sewage septic tank effluent progressed, during the first several days, in proportion to the suspended solids added. Following this, biological activity appeared to take effect to reduce the rate of clogging. Studies of the application of normal and disinfected effluents to soil resulted in a more rapid rate of clogging for the disinfected effluent, further indicating that biological activity in this case appeared to reduce the rate of clogging.

A comparison of the clogging rates of effluent from a septic tank receiving sewage and ground garbage, with the effluent from a septic tank receiving sewage only, indicated a more rapid rate of clogging for the garbage-sewage loaded tanks effluent both on a time and solids applied basis. The two soils used were a heavy reddish brown clay and a silty clay. Based on the laboratory data, the additional area which would have been required for the cores receiving the garbage-sewage tank effluent to pass equal volumes of effluent in the same time as the cores receiving sewage effluent only, or to develop a comparable rate of clogging after equal amounts of suspended solids were added would be roughly twenty to thirty-five per cent. This is, of course, merely academic until more data are available upon which to base definite conclusions. However, there is here indication that for the limited types of soil investigated an increase in soil absorption area may be necessary where the wastes discharged to the septic tank include ground garbage.

If I were building a system for myself right now I would be inclined to increase the usual unit absorption area requirements for sewage loadings by 50 per cent to provide for the inclusion of ground garbage waste.

The above is of course merely a status account of our studies so far as they concern the ground garbage topic. Much remains to be done, particularly field work. In the meantime the best advice I can give is to avoid skimping on capacity, either in the tank or the absorption field.

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Table of Most Probable Numbers
per 100 ml. of Sample Planting 10 Portions
each of 10 ml., 1.0 ml. and 0.1 ml.
(Numbers of Positive Tubes)

10	1	.1	M.P.N.	10	1	.1	M.P.N.	10	1	.1	M.P.N.
0	0	0	<0.90	7	3	2	19	8	7	3	39
0	0	1	0.90	7	4	0	17	8	7	4	42
0	1	0	0.91	7	4	1	19	8	7	5	46
0	2	0	1.8	7	4	2	21	8	8	0	34
				7	5	0	19	8	8	1	37
1	0	0	0.94	7	6	0	21				
1	1	0	1.9					8	8	2	40
1	2	0	2.9	8	0	0	13	8	8	3	43
				8	0	1	15	8	8	4	47
2	0	0	2.0	8	1	0	15	8	8	5	50
2	1	0	3.0	8	1	1	17	8	9	0	37
2	2	0	4.0	8	1	2	19				
								8	9	1	40
3	0	0	3.2	8	2	0	17	8	9	2	44
3	1	0	4.2	8	2	1	19	8	9	3	47
3	2	0	5.3	8	2	2	21	8	9	4	51
				8	2	3	23	8	9	5	55
4	0	0	4.5	8	3	0	19				
4	0	1	5.6					8	9	6	59
4	1	0	5.6	8	3	1	21	8	9	7	63
4	2	0	6.8	8	3	2	24	8	9	10	75
				8	3	3	26	8	10	0	41
5	0	0	6.0	8	3	4	29	8	10	1	45
5	0	1	7.2	8	4	0	22				
5	1	0	7.3					8	10	2	48
5	2	0	8.5	8	4	1	24	8	10	3	52
5	3	0	9.9	8	4	2	26	8	10	4	56
5	4	0	11	8	4	3	29	8	10	5	60
				8	4	4	32	8	10	6	64
6	0	0	7.8	8	4	5	35				
6	0	1	9.2					8	10	7	68
6	1	0	9.2	8	5	0	24	8	10	8	72
6	2	0	11	8	5	1	27	8	10	9	76
6	3	0	12	8	5	2	29				
6	4	0	14	8	5	3	32	9	0	0	17
6	5	0	15	8	5	4	35	9	0	1	19
								9	1	0	19
7	0	0	10	8	5	5	38	9	1	1	22
7	0	1	12	8	6	0	27	9	1	2	25
7	1	0	12	8	6	1	30				
7	1	1	13	8	6	2	33	9	2	0	22
7	2	0	13	8	6	3	36	9	2	1	25
								9	2	2	28
7	2	1	15	8	6	4	39	9	2	3	32
7	2	2	17	8	6	5	42	9	3	0	25
7	3	0	19	8	7	0	30				
7	3	0	15	8	7	1	33				
7	3	1	17	8	7	2	36				

10	1	.1	M.P.H.	10	1	.1	M.P.H.	10	1	.1	M.P.H.
9	3	1	29	9	9	3	76	10	5	0	62
9	3	2	32	9	9	4	83	10	5	1	74
9	3	3	36	9	9	5	90	10	5	2	87
9	3	4	40	9	9	6	97	10	5	3	100
9	4	0	29	9	9	7	100	10	5	4	120
9	4	1	33	9	9	8	110	10	5	5	130
9	4	2	37	9	9	9	120	10	6	0	79
9	4	3	41	9	9	10	130	10	6	1	94
9	4	4	45	9	10	0	65	10	6	2	110
9	4	5	50	9	10	1	72	10	6	3	120
9	5	0	33	9	10	2	79	10	6	4	140
9	5	1	37	9	10	3	86	10	6	5	160
9	5	2	42	9	10	4	93	10	6	6	180
9	5	3	46	9	10	5	100	10	7	0	100
9	5	4	51	9	10	6	110	10	7	1	120
9	5	5	57	9	10	7	120	10	7	2	140
9	6	0	38	9	10	8	120	10	7	3	150
9	6	1	43	9	10	9	130	10	7	4	170
9	6	2	47	9	10	10	140	10	7	5	190
9	6	3	53	10	0	0	23	10	7	6	220
9	6	4	59	10	0	1	27	10	7	7	240
9	6	5	65	10	1	0	27	10	8	0	130
9	7	0	44	10	1	1	32	10	8	1	150
9	7	1	49	10	1	2	38	10	8	2	170
9	7	2	54	10	2	0	33	10	8	3	200
9	7	3	60	10	2	1	39	10	8	4	220
9	7	4	66	10	2	2	46	10	8	5	250
9	7	5	71	10	2	3	54	10	8	6	280
9	8	0	50	10	3	0	40	10	8	7	310
9	8	1	55	10	3	1	47	10	8	8	350
9	8	2	61	10	3	2	56	10	9	3	260
9	8	3	68	10	3	3	66	10	9	4	300
9	8	4	74	10	3	4	77	10	9	5	350
9	8	5	80	10	4	0	49	10	9	6	400
9	8	6	87	10	4	1	59	10	9	7	460
9	8	7	94	10	4	2	70	10	9	8	530
9	8	10	110	10	4	3	82	10	9	10	680
9	9	0	57	10	4	4	94	10	10	0	560
9	9	1	63	10	4	5	110	10	10	1	290
9	9	2	70					10	10	2	350
								10	10	3	430
								10	10	4	540
								10	10	5	700
								10	10	6	920
								10	10	7	1,200
								10	10	8	1,600
								10	10	9	2,300
								10	10	10	>2,300

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